Washington Forest Practices Adaptive Management Science Conference

Conference Program

March 20, 2007

Cooperative Monitoring Evaluation and Research (CMER)
Washington Department of Natural Resources
Olympia, WA

Cooperative Monitoring Evaluation and Research

The Washington Forest Practices Board (FPB) has adopted an adaptive management program in concurrence with the Forests and Fish Report (FFR) and subsequent legislation. The purpose of this program is to:

> Provide science-based recommendations and technical information to assist the board in determining if and when it is necessary or advisable to adjust rules and guidance for aquatic resources to achieve resource goals and objectives. (Forest Practices Rules, WAC 222-12-045)

To provide the science needed to support adaptive management, the FPB made the Cooperative Monitoring, Evaluation and Research Committee (CMER) a participant in the program. The FPB empowered CMER to conduct research, effectiveness monitoring, and validation monitoring in accordance with guidelines recommended in the FFR

Additional information about the CMER program is available at:
http://www.dnr.wa.gov/forestpractices/adaptivemanagement/

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Conference Agenda

Early Morning Session

8:45 am	**Introduction**	Doug Martin, Co-Chair CMER
8:55 am	Description of Treatment Basins for the Type N Experimental Buffer Treatment Study	Aimee McIntyre, WDFW
9:20 am	First Pre-harvest Year Amphibian Data for the Type N Experimental Buffer Treatment Study	Marc Hayes, WDFW
9:45 am	Landscape Genetics of Tailed Frogs (*A. truei*) in Reference Versus Managed Basins	Stephen Spear and Andrew Storfer, WSU
9:58 am	Comparative Patterns of Gene Flow and Dispersal in Sympatric Species of Giant Salamanders (Dicamptodon)	Craig Steele and Andrew Storfer (presenter), WSU
10:10 am	Question and Answer Session	
10:20 am	**Break**	

Late Morning Session

10:35 am	Suspended Sediment Export from Type N Basins: Methodology and Data Analysis	Bill Ehinger, WDOE
11:00 am	Terrestrial Salamander Wood Utilization in Managed Landscapes: Forestry Practices Implications	Marc Hayes, WDFW
11:25 am	Effects of Shade Retention on Stream Amphibians: Some Preliminary Results	Jim MacCracken, Longview Fibre
11:50 am	Question and Answer Session	
12:00 pm	**Lunch**	

Early Afternoon Session

1:00 pm	Effectiveness of Buffer Prescriptions in Protecting and Maintaining Shade, Solar Energy, and Water Temperature in Forested Streams of Eastern Washington: Shade Findings	Eddie Cupp, Terrapin Environmental
1:25 pm	Continued: Solar Radiation Findings	Mike Bonoff, Mason, Bruce & Girard.
1:50 pm	Type N BCIF Riparian Buffer Stand Development and Mortality	Ash Roorbach, CMER-NWIFC
2:05 pm	Tree Fall and LWD Recruitment in Westside Type N Buffers	Dave Schuett-Hames, CMER-NWIFC
2:25 pm	Soil Disturbance and Channel Wood Loading in Westside Type N Buffers	Greg Stewart, CMER-NWIFC
2:40 pm	Question and Answer Session	
2:50 pm	**Break**	

Late Afternoon Session

3:05 pm	Salmonids in Headwater Streams: Movement Characteristics and Barrier Impacts	Robert Hoffman and Jason Dunham, USGS-FRESC
3:30 pm	Road Sub-Basin Monitoring Project: Lessons Learned from Phase 1	Jenelle Black, CMER-NWIFC
3:55 pm	Landslide Hazard Zonation Mapping: Quantification of Landslide Response to Severe Storms and Forest Management in the Sultan Basin, Washington	Isabelle Sarikhan, WDNR
4:20 pm	Question and Answer Session	

Posters

All Day	Effectiveness of Washington Forest Practices at Reducing Landslide Rates and Volumes: A Study Design	Julie Dieu, Rayonier
All Day	Landslide Hazard Zonation Project 4th Year Status Report	Laura Vaugeois, WDNR
All Day	The Effectiveness of Unstable Landform Identification Project: Detecting Accuracy and Bias in the Process	Abby Hook, Tulalip Tribe

Abstracts

Road Subbasin Monitoring Project-Lessons Learned from Phase 1

Jenelle Black

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The Subbasin-Scale Road Monitoring Project is an ongoing study of the potential for forest roads in Washington subject to the Forest and Fish Rules (FFR) to deliver fine sediment to stream channels via surface erosion. Forest practice rules, including development of road maintenance and abandonment plans for large forest landowners, were strengthened in 2001 with the intent to reduce the potential for forest roads on state and private lands to deliver surface erosion sediment to the stream network. This project investigates the current state of factors known to contribute sediment on roads across the state, and will review the status at five-year increments through 2016 in order to assess change. The study goal is to assess whether the implementation of these more stringent road maintenance rules results in an overall improvement in the conditions of roads subject to FFR in Washington over the 15-year implementation period. Small forest landowner properties, which are subject to somewhat different rules than large forest landowners are included in this study.

Phase I of the initial survey event was completed in 2006. This talk will focus on lessons we learned in implementing this phase of a statewide forest monitoring project that involves multiple landowners at each study site. Of particular note are the intricacies and delicacy involved in gaining trust and cooperation from small landowners in eastern Washington. I found it is important with all landowners to present a united, consistent CMER and research front. There are some resources and procedures within CMER that can help achieve that. Many of these things could perhaps also be used by other similar non-CMER projects to enhance the overall effort to obtain needed information about land management influences. The more we can coordinate efforts and show landowners we are not antagonistic to conditions on their property, the more confidence landowners will have in working with us and the more accurate our understanding of forest land status and rules effects will be.

Effectiveness of buffer prescriptions in protecting and maintaining shade, solar energy, and water temperature in forested streams of Eastern Washington: Solar Radiation Findings

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Eastern Washington riparian timber harvest prescriptions, pertaining to shade, differ depending on whether or not a harvest unit is within the Bull Trout Habitat Overlay. When a harvest unit is located within the habitat overlay, "all available shade" must be retained within 75 feet of the bankful width or channel migration zone, whichever is greater. When a harvest unit is located outside the habitat overlay, prescriptions fall under the standard shade rule, which may allow for harvest of a portion of shade trees within 75 feet, depending on elevation and canopy cover existing prior to harvest. This study is focused on streams managed within the bull trout overlay, and looks specifically at whether the "all available shade" rule, which relies on densiometer measurements of canopy cover, is effective at blocking solar energy from reaching the stream.

The solar study uses simultaneous (paired) measurements in no-harvest (reference) and harvested (treatment) reaches to assess changes in solar radiation following harvest. A third instrument at a nearby hilltop location monitors unobstructed sunlight to allow measurement of attenuation at each stream site (percent available radiation, PAR). Each site consists of a 300 meter reference reach upstream of a 300 meter treatment reach. Solar radiation data are collected at 50-meter intervals within each reach. Crews remain at a given monitoring site for five minutes, recording data at 1-minute intervals, before moving to the next location. Over the course of the day, six observations are made at each station, resulting in a total of 150 individual observations in each reference and treatment reach.

Field crews completed pre-harvest data collection during the 2003-2006 field seasons. Pre-harvest PAR was low; less than 20 percent at all sites, suggesting that attenuation of solar energy is high and relatively constant at these streams, regardless of cloud conditions.

To date, harvest has occurred at three sites within the bull trout habitat overlay; Dry Canyon Creek, Mill Creek, and Upper Bacon Creek. All three sites were visited for post-harvest data collection during the 2006 field season. Analysis of these data is ongoing; however, PAR in the treatment reaches increased to 7.6% from 4.2% at Dry Canyon, and to 3.6% from 2.9% at Mill Creek. Little change was seen at Upper Bacon Creek, where treatment reach PAR increased to 4.6% from 4.3%. While the absolute changes in energy (W/m^2) are small, the incremental changes in PAR observed post-harvest are large; over 80 percent greater PAR at Dry Canyon, and more than 20 percent greater PAR at Mill Creek. Although preliminary, these increases may be attributable to a treatment effect, while the small change at Bacon Creek may be influenced by aspect and/or topographic relief relative to Dry Canyon and Mill Creek.

Effectiveness of riparian management zone prescriptions in protecting and maintaining shade, solar energy, and water temperature in forested streams of Eastern Washington: Shade Findings

Eddie Cupp

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As part of the Forests and Fish Adaptive Management Program, the Bull Trout Scientific Advisory Group is administering a study addressing the effectiveness of the forest practices rules for Eastern Washington in protecting and maintaining shade and stream temperature. The study uses a modified before/after, control/impact experimental design to test the effectiveness of two riparian prescriptions: the bull trout habitat overlay (i.e., "all available shade") rule and the standard rule which uses a shade nomograph. Each site consists of a 300-m reference reach with no harvest activity immediately downstream of a 300-m treatment reach where one of the two riparian prescriptions is applied. Continuous temperature recorders are installed in the stream at 150-m intervals between the upper boundary of the reference reach and the lower boundary of the treatment reach. Canopy cover and stream temperatures are being measured for at least two summers before and two summers after riparian harvest. The analysis will test for a treatment effect by determining if there is a change in temperature between the reference and treatment reaches pre- and post-harvest.

The study is going into its fifth field season. A total of 37 sites have been established for study inclusion. Under pre-treatment conditions, the study sites are all well shaded (mean canopy closure - 92%) with relatively cool stream temperatures (mean daily maximum water temperature = 10.7 ˚C; range: 5.2 ˚C – 18.9 ˚C). To date, harvest treatments have been completed on four sites; treatment has begun on another seven sites. Preliminary data on the four harvested sites will be presented.

Effectiveness of Washington Forest Practices at Reducing Landslide Rates and Volumes: A Study Design

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This study design to evaluate the effectiveness of Washington State Forest Practices at reducing landslide rates and volumes is unique in three respects: 1) Existing landslide and forest management data have been used in an attempt to establish a sample design likely to provide statistically significant landscape-scale comparisons between past and present forest practices; 2) Triggering mechanisms of individual landslides will be field-identified to provide information about individual rules and best management practices at the site-scale; 3) When a large storm in Washington State triggers a population of new landslides, aerial photography and field work will initiate from existing contracts. Optimizing sample size was critical to developing a practical field sampling protocol within limitations of time and funding. Data from previous regional landslide studies in the forested Pacific Northwest provided guidance for identifying the smallest possible blocks likely to contain a sufficient number of landslides in each of the strata to recognize statistically significant differences in landslide density between them. Sample design includes delineation of five harvest strata and five road strata. These strata represent different stand ages and types of unstable slope buffering, and different levels of design and maintenance for roads. In the detailed analysis of individual landslides particular focus has been placed on disturbance triggers associated with harvest (e.g., yarding corridors) and on a wide variety of road triggers including inadequate drainage, undersized stream-crossing pipes, poor prism maintenance, and lack of sidecast pullback. The occurrence of these triggers will be compared with new rules and BMPs designed to preclude them. There will be two contracts in place, one for acquisition and development of 1:12,000-scale aerial photography of the affected area in the spring following the storm, and one for the delineation of strata per the sample design, followed by field inventory of landslides and analysis of these data.

Suspended sediment export from Type N basins-methodology and data analysis

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This five year study, initiated in summer 2006, employs Turbidity Threshold Sampling to estimate suspended sediment transport to downstream fish-bearing reaches. TTS uses relatively recent technological development of *in situ* turbidity sensors to trigger sample collection via a pump sampler. Of the 18 basins in the Type N Experimental Buffer Study, eight were selected, based on year-round access and the presence of a suitable site for equipment installation.

Each stream is instrumented to measure flow (Montana style flume or *in situ* flow-velocity meter), stage height (pressure transducer), and turbidity at 10 minute intervals. The pump sampler is triggered to collect a water sample for analysis of suspended sediment concentration when turbidity exceeds specific pre-set turbidity thresholds. Because of the strong correlation between turbidity and suspended sediment concentration (SSC), we can use turbidity to estimate SSC and develop a continuous estimate of suspended sediment transport (SSC times flow). This continuous estimate may then be summed into annual loads or parsed by individual storm events.

This presentation will describe the equipment installation, the data collected, and the planned analyses. We will also review some of the challenges posed by 1) working in very small streams; and 2) maintaining quality control of continuously collected data.

First Pre-Harvest Year Amphibian Data for the Type N Experimental Buffer Treatment Study

Marc Hayes[1], Aimee McIntyre[1], Casey Richart[1], and Tim Quinn[1]

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The Washington State Department of Fish and Wildlife is implementing the amphibian demographic response portion of the Type N Experimental Buffer Treatment Study. Amphibians will be sampled to identify potential treatment-specific changes in occupancy and density at each of 18 Type N (non-fish-bearing headwater) basins. Target amphibian species are stream-associated and include: coastal tailed frog (*Ascaphus truei*), three species of torrent salamander (*Rhyacotriton*), and two species of giant salamander (*Dicamptodon*).

We are collecting demographic data using two methods: longitudinal light-touch and rubble-rousing. To date, we have completed amphibian sampling at all 18 basins for the first pre-treatment year (2006). During longitudinal light-touch sampling, all moveable objects on the streambed gravel-sized and larger are overturned to increase likelihood of detection. This method provides life-stage specific presence/absence information for all amphibian species encountered, and relative abundance for some. Rubble-rousing, used to estimate amphibian density, involves block netting the up- and downstream ends of randomly chosen 1-m reaches. Within these reaches, all substrate gravel-sized and larger is removed from the stream channel, and remaining fines are sifted to locate amphibians.

To date, we have completed light-touch and block net sampling on all 18 basins for the first pre-treatment year (2006). In total, 13 amphibians species were detected across all basins using the longitudinal light-touch method. During pre-study occupancy verification surveys in 2005, *A. truei* was detected at all 18 basins s (a criterion for site selection), *Rhyacotriton* at 13, and *Dicamptodon* at 14. Using longitudinal light-touch in 2006, *A. truei* was detected at 15 sites, *Rhyacotriton* at 17 and *Dicamptodon* at all 18.

Using rubble rousing in 2006, *A. truei* was detected at 12 basins , *Rhyacotriton* at 14, and *Dicamptodon* at all 18. At basins where the species were detected the mean number of individuals per 1-m stream reach ranged from 0.05 (SD = 0.22) to 1.85 (SD = 3.80) for *A. truei*, 0.05 (SD = 0.22) to 3.9 (SD = 4.78) for *Rhyacotriton,* and 0.05 (SD = 0.22) to 3.25 (SD = 4.78) for *Dicamptodon*. The number of *Rhyacotriton* detected per 10-m stream reach using light-touch was highly correlated to the number detected per 1-m stream reach using rubble-rousing (Spearman Rank Correlation, $\rho = 0.779$, $p = 0.0013$). Coefficients of variation (CV) by basin for both light-touch and rubble rousing sampling were typically ≥ 1.

Terrestrial salamander wood utilization in managed landscapes: Forestry practices implications

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We studied the importance of wood to terrestrial salamanders in managed forest landscapes in southwestern Washington in a study designed around Dunn's salamander (*Plethodon dunni*), but which also obtained data on ensatina (*Ensatina eschscholtzii*), Van Dyke's salamander (*Plethodon vandykei*), and western red-backed salamander (*Plethodon vehiculum*). During April-June, we intensively sampled 10 2-m wide belts perpendicular to the stream axis at 14 sites in 2001 and 5 sites in 2003. We partitioned belts into streambanks and uplands, measured or scored habitat within each, and characterized microhabitats in which terrestrial salamanders were found.

All four species of terrestrial salamander had some association with wood, but marked differences were evident, in particular for the two Forests and Fish terrestrial salamander species: Dunn's salamander and Van Dyke's salamander. Our data on Dunn's salamanders validate that obtained over its extra-Washington State range, namely, that it displayed the most frequent association with inorganic substrates and least frequent association with wood among the four terrestrial salamander species sampled. Moreover, Dunn's salamander density was uncorrelated with amount of available wood, implying that salamander abundance may be independent of the availability of wood. However, inorganic substrates do not appear to be limiting across study sites and may constrain the latter conclusion. Dunn's salamander used wood significantly more frequently in uplands, which were drier, than along streambanks, which were moister. This implies that dependence on wood may be habitat dependent. The latter pattern was also evident in western red-backed salamanders.

In contrast, Van Dyke's salamanders were not only the terrestrial salamander species most often associated with wood, but they used the largest size category (> 50 cm diameter) of wood, and appeared to be using it at a higher frequency than seemed available. However, there is a potentially high likelihood of false negative errors because some sites sampled fell outside the range of physical conditions recommended for sampling Van Dyke's salamander, thereby limiting this conclusion. Further study of the use of large wood by Van Dyke's salamanders in headwater streams needs study because of the potential for forest buffers to contribute to the amount and characteristics of large wood available in riparian areas.

Salmonids in Headwater Streams: Movement Characteristics and Barrier Impacts.

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Movement is an essential mechanism by which mobile animals acquire the resources necessary for the successful completion of their life-cycles. It also plays a crucial role in how animals are distributed across the landscape and the persistence of populations and species. Research has shown that salmonids in headwater streams can be quite mobile, that their patterns of movement are diverse and vary relative to species, and that movement is fundamental to the persistence of populations across generations. Salmonids are the fish species most often found at the upper limits of headwater streams in the western United States. They are well adapted to life in these streams and have evolved behaviors useful for exploiting the many types of headwater stream habitats. Yet, to be able to utilize these habitats, individuals must be able to access them. Salmonids have coexisted with and adapted to the presence of naturally occurring barriers to upstream movement in headwater streams. However, human-placed movement barriers to the upstream movement of salmonids create additional impediments that can negatively affect the persistence of populations and species in these habitats. This presentation will summarize what is generally known about the diversity of movement among native salmonid species in headwater streams of the western US, identify factors that influence their presence and persistence in these freshwater systems, and discuss results of recent studies that have examined potential impacts of human-placed barriers to salmonid movement and population/species persistence.

Effects of Shade Retention on Stream Amphibians: Some Preliminary Results

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The Forest and Fish prescription for non-fish bearing streams requires 50% of the length to be buffered and an equipment exclusion zone for the remaining 50%. The effect of reductions in shade from harvest and buffer blowdown on amphibians is unknown. We are conducting a replicated before-after, control-impact study, evaluating 4 levels of shade retention (0%, 33%, 67%, and full shade). Study sites range from northwest Oregon to the Olympic Peninsula and response variables include light infiltration, biofilm accumulation, macroinvertebrate and organic matter drift, and amphibian abundance, growth rates, and body condition. Two seasons of pre-treatment data and 1 of post-treatment data on will be presented for study sites in northwest Oregon and southwest Washington.

Description of Treatment Basins for the Type N Experimental Buffer Treatment Study

Aimee McIntyre[1], Marc Hayes[1], Casey Richart[1], William Ehinger[2], Robert Bilby[3], Stephanie Estrella[2], Tiffany Hicks[1], James MacCracken[4], Timothy Quinn[1],
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The Type N Experimental Buffer Treatment Study is a Washington State Forest Practices Cooperative Monitoring Evaluation and Research (CMER) Committee funded study that will evaluate the effectiveness of Forest Practices riparian buffers along non-fish-bearing (Type N) streams in western Washington. This harvest-unit level evaluation of buffer effectiveness will provide valuable information for the adaptive management of headwater streams on Washington State Lands. The design includes four treatments and will compare Forest Practices (FP) buffers (50% of the stream reach with a 50-foot buffer) to buffers of greater length (100% of the stream reach with a 50-foot buffer), lesser length (0% of the stream reach buffered), and an unharvested reference. Analyses will distinguish potential differences among treatments and assess the ability of each buffer prescription to maintain headwater habitat and system functions.

A complex 2-year site selection effort began in June 2004 and involved a 4-tiered process including: 1) GIS screening of basins meeting specified criteria; 2) acquisition of landowner information; 3) field verification of GIS information and target amphibian presence; and 4) verification of fish end point. This effort resulted in the inclusion of 18 Type N Study basins. Blocks of four treatment basins, each representing an entire harvest unit, are replicated 4 times; two back-up sites are also included for a total of 18 basins. Of the 18 basins, 4 will receive the 0% buffer treatment, 4 will receive the FP buffer treatment, 5 will receive the 100% buffer treatment, and 5 will act as unharvested references. Blocks are located on the Olympic Peninsula (1 block), in the Willapa Hills of southwest Washington (2 blocks), and in the south Cascades (1 block). Both backup sites are located in the Willapa Hills.

Most basins represent 2nd order streams. Mean basin size (n = 18) is 28.4 hectares (70.2 acres), and range from 12.5 hectares (30.8 acres) to 75.9 hectares (187.5 acres). Total stream length from the fish end point to the uppermost point of perennial stream flow, including all tributaries in a basin, averages 1296.1 m, and ranges from 325 m to 3449 m.

Type N BCIF riparian buffer stand development and mortality

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The west-side Type N Buffer, Characteristics, Integrity and Function (BCIF) study monitors the development and functions of riparian stands along fishless perennial streams in western Washington. Study sites were randomly selected from forest practices applications submitted to the Washington Department of Natural Resources that included one or both of the following buffer prescriptions: 2-sided 50' wide no-cut buffers along type N streams and 56 foot radius no-cut buffers at perennial stream flow initiation points (PIPs). Each treatment site was paired with a nearby un-harvested reference site. Sites were harvested in 2003. Collected data include: riparian tree conditions and characteristics, shade, understory plant communities, fallen and stream-recruited trees, in-stream wood loading, and wind-throw related soil disturbances.

In 2006 we collected tree data at 14 sites, which included 12 50' buffers, 3 PIP buffers and 13 reference sites (one of the reference sites had been harvested). We found differences in basal area (BA) in both the 50' buffers (162.5 sq. ft. per acre) and PIP buffers (177.3 sq. ft. per acre) versus the reference sites (217.1 sq. ft. per acre). We also found differences in tree density in the 50' buffers (127.5 trees per acre) and PIP buffers (117.9 trees per acre) versus the reference sites (218.1 trees per acre). Tree mortality that occurred post-harvest was also higher in the 50' and PIP buffers than in the references sites. The most common identified cause of post-harvest mortality (as a percentage of dead basal area) in the 50' and PIP buffers was windthrow (49% and 84.7%, respectively). In the reference sites windthrow (21.9%) and suppression (21.8%) were the most common identified causes of mortality, though mortality which could not be conclusively identified to a cause represented the highest percentage in these sites (45%). Over 90% of the post-harvest mortality of trees in the reference sites remained standing as snags while 51% and 62% of the post-harvest dead trees in the 50' and PIP buffers, respectively, remained standing. We also observed higher incidence of damage to standing live trees in the 50' buffers (15.4% of live BA) and PIP buffers (10% of live BA) versus 6.5% of live BA in the reference sites. The presence of large scars was the most common observed damage condition in reference sites and 50' buffers (28.6% and 27% of damage, respectively) while 'leaning' was the most common observed damage in the PIP buffers (48.5%).

We were able to estimate pre-harvest stand conditions using data collected 3 years after harvest, though the uncertainty associated with determining whether trees were alive or dead pre-harvest made doing trend analysis problematic. Nonetheless, combining current stand conditions with observed patterns of tree mortality suggest that three years after harvest stands in the riparian buffers are on different developmental pathways than stands in the reference sites. Exposure to increased wind disturbance in the buffers has increased the relative amounts of dead wood in the stands and that much of this wood has fallen. There is much less mortality in the control sites and the dead wood that has been created in the last 3 years for the most part remains standing. The relatively higher incidence of leaning trees in the PIP buffers also suggest that 3 years after harvest these buffers have yet to become wind-firm though the small sample size of this buffer type (n=3) cautions against drawing too large an inference.

Landslide Hazard Zonation Mapping: Quantification of Landslide Response to Severe Storms and Forest Management in the Sultan Basin, Washington

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As part of a statewide effort to map unstable landforms in forested watersheds, landslides and landforms in the Basin were inventoried based on aerial photographs dating from the 1950's to 2000's and reconnaissance field work. During the study, 1,126 landslides were identified and subdivided into various categories, such as landslide type, landuse, and delivery. On the basis of air photos and field information, landforms were mapped for the Sultan River Basin. Three criteria were used in mapping landforms: 1) Washington State Forest Practices rules definitions, 2) the landslide inventory demonstrated the landforms' instability, or 3) no landslide hazard areas. In identified unstable areas, the key geomorphic components of the landform were identified and extrapolated to other parts of the watershed with similar features. The landslide inventory was also used to calculate the level of hazard delivered for each landform, using two metrics: landslide density per landform area and landslide area per landform area. The purpose of two metrics is to quantify, for every landform, how likely failures and probable impact from failures in this landform, using area as a proxy for volume. Along with metrics, landslide triggering mechanisms are compiled for each landform to provide managers and regulators with the necessary information to determine whether a specific practice on a landform is likely to cause adverse environmental impact. In addition to landuse effects on landslide triggers, storm systems have played a major role in landslide failures and accelerated sediment delivery. Aerial photo flights were selected specifically after large hydrologic storm events. Historic photographs show many landslides to be associated with forest roads, however, as roads were abandoned or upgraded to current standards, the frequency of debris flows and shallow landslides decreased.

Tree fall and LWD recruitment in Westside Type N Buffers

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This paper presents a preliminary analysis of tree fall and LWD recruitment data for perennial non-fish bearing streams in western Washington where patch-cut riparian buffer prescriptions were used under the state forest practices rules. Two types of buffers were observed at the study sites. The 50 ft buffers are continuous no-cut buffers extending out 50 ft on both sides of the stream (n=12).. PIP buffers are isolated 56 ft radius circles around points where perennial flow begins (n=3). Unharvested paired reference sites were included for comparison purposes.

Of 6791 trees standing at the beginning of the study, 545 (8%) had fallen three year later (2.7% annual rate). The fall rate in trees per acre (TPA) was greater in the PIP buffers (88 TPA) and the 50 ft buffers (32 TPA) than in the reference sites (4 TPA). Only 211 (47%) fallen trees recruited either into (8%) or over (39%) the channel. Most over-channel trees spanned the channel, in contact with the ground on both sides. Nearly 85% of trees that fell were conifers. About 9% of the original standing conifers fell compared to 5% of the broad-leafs, for an annual rate of 2.9% and 1.7% respectively. The mean diameter breast height (DBH) of conifers (12.3 in) was larger than broad-leafs (10.6 in). Conifers comprised 80-90% of fallen trees in both buffer types. The ratio was nearly equal in the reference sites. Nearly 60% of fallen trees were western hemlock. Red alder and Douglas-fir contributed about 10% each. Pacific silver fir had the highest percentage of trees falling (38% of original trees) followed by western hemlock (12%) and red cedar (10%). Red alder (5%), Douglas-fir (3%) and big-leaf maple (2%) fell less frequently.

Fallen trees were classified as uprooted (roots remained attached) or broken (bole sheared off above ground). The proportion of uprooted (70%) to broken (30%) was similar for both buffer types and the references. Uprooted trees (48%) reached the channel edge more frequently than broken trees (43%). However a greater proportion of broken trees recruited into the channel (13% vs. 6%). Breakage appeared to facilitate entry into the small channels. Uprooted trees were more likely to hang over the channel (42% vs. 30%). Wind was the most frequent fall process (64%), creating both uprooted and broken trees. Other fall processes included trees knocked down by others (16%) and decay associated with suppression mortality or disease (3%). Tree fall due to bank erosion was minor (1%) for these small streams. Wind was the dominant fall process in the PIP buffers and 50 ft buffers (75% and 60%, respectively). No fall process dominated in the reference sites. About 2/3 of the trees fell towards the north. This is likely due to strong southerly winds associated with low pressure winter storm systems. This pattern was prominent in the PIP buffers where over 75% of the trees fell in a northerly direction. Overall, the percentage of fallen trees originating within 25 ft of the stream was similar to that from 25-50 ft. However, over 60% of fallen trees in PIP buffers came from beyond 25 ft. Trees within 25 ft were more likely to hit the channel, providing 55% of the recruiting trees. Mean distance-to-stream for trees entering the channel was 19 ft, compared to 21 ft for trees falling over the channel and 27 ft for trees missing the channel.

The mean total volume of LWD recruited varied greatly by buffer type, ranging from over 300 cu ft per acre for PIP buffers to approximately 115 cu ft/acre for 50 ft buffers. Values for reference sites were much lower by comparison (7 cu ft/acre), while LWD recruitment in clear cut reaches was almost non-existent (1 cu ft/acre). About half the total LWD volume was in the bank full channel in the PIP buffers, while the vast majority of recruitment in the 50 ft buffers was spanning or suspended over the channel.

Landscape genetics of tailed frogs (*Ascaphus truei*) in reference versus managed basins

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The coastal tailed frog (*Ascaphus truei*) is a stream-associated Pacific Northwest FFR species thought to be especially sensitive to environmental disturbance. Therefore, it has often been assumed that timber harvest reduces population connectivity. However, results from previous studies have produced different conclusions in various landscapes. To address this issue, we used a landscape genetic approach to identify key landscape and habitat variables that influence population structure. This study is part of the larger Type N project to assess the effect of different timber harvest buffers on FFR amphibian species. Prior to Type N managed harvest, which is scheduled for 2008 or 2009, we set out to understand genetic connectivity and genetic neighborhood in reference sites and managed sites to make predictions as to what will happen post-harvest. We have assessed genetic population structure in old-growth forests of Olympic National Park (reference) and managed forests of Olympic National Forest to test if timber harvest altered genetic structure and ecological associations. We used a spatial regression analysis to test the correlations of specific landscape variables relevant to tailed frog ecology with gene flow. Results indicate that variables such as drainage, solar radiation, and non-forest cover type appear to constrain movement within regions, but that overall gene flow is high within the Olympic National Park. Timber harvest was associated with reduced genetic connectivity in the Olympic National Forest. In addition, while slope and precipitation are not significant within each of the two study regions, both variables explained a significant difference in gene flow between the National Park and forest. This implies that broader climatic and topographic factors may also be important for tailed frog population structure.

Comparative patterns of gene flow and dispersal in sympatric species of giant salamanders (*Dicamptodon*)

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Cope's giant salamander (*Dicamptodon copei*) is a stream-associated species endemic to the Pacific Northwest with a disjunct distribution. We present results from a study examining gene flow patterns between *D. copei* and the sympatric Pacific giant salamander (*D. tenebrosus*). Metamorphosis into a terrestrial adult is extremely rare in *D. copei*, while the opposite is true for *D. tenebrosus*. We predicted that the different frequencies of terrestrial adults will affect relative rates of gene flow, resulting in higher levels of genetic connectivity among populations of *D. tenebrosus* than *D. copei*. Because migration between populations can occur either via direct overland dispersal or along waterways, we also test whether population structure is best explained by overland versus stream dispersal. Movement between populations of *D. tenebrosus* is hypothesized to occur primarily by overland dispersal of terrestrial adults, resulting in patterns of population structure best explained by terrestrial distance between streams. In contrast, *D. copei* individuals are constrained to their natal streams and migration among localities is predicted to occur primarily along stream routes. Using microsatellite loci, we tested the general prediction that higher levels of genetic connectivity exist for metamorphosing populations of *D. tenebrosus* than for non-metamorphosing *D. copei* and test patterns of genetic structuring against the two dispersal models. Results suggest that gene flow and the genetic neighborhood of *D. copei* is much smaller than that of *D. tenebrosus* and that *D. copei* gene flow tends to follow stream routes. Across the study area, there was very little genetic structuring of *D. tenebrosus*, as expected with a terrestrial species. This study is part of the larger Type N project to assess the effect of different timber harvest buffers on amphibian species and was conducted in one of the Type N study blocks in the South Cascades.

Soil disturbance and channel wood loading in Westside Type N Buffers

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Following 2004 analysis of west side Type N Buffer Characteristics, Integrity and Function (BCIF) study results, the Riparian Science Advisory Group (RSAG) decided to add two new metrics to the study: 1) channel wood loading and 2) soil disturbance associated with windthrow. Data collected during the summer of 2006 show that the percentage of bank full channel area obscured by woody debris residing entirely above the plane of the bank full channel is significantly greater in treatment sites when compared against reference sites ($p=0.025$, $n=13$). No statistically significant differences were noted for hydraulically active wood. Increases in suspended wood were almost completely attributable to clear-cut sites, which had 3x as much suspended debris cover as the reference or buffered sites (50' or PIP). Soil disturbance associated with uprooted trees (primarily due to windthrow) was greatest in PIP Buffers, followed by 50' Buffers, and Reference sites resulting in higher sediment yields at each treatment types respectively. Within the three year timeframe of the study, sediment yields from uprooted tree pits were significantly greater at treatment sites ($p=0.036$, $n=13$) and appear to be about twice that found at reference sites. Sediment yields in reference sites, and increases associated uprooted trees in patch cut buffers, are on the same magnitude as those reported for soil creep, and appears to be significantly less than produced by other episodic mass-wasting events like debris flows.

Washington State's Landslide Hazard Zonation Project: Status Report

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Landslides are a common, naturally occurring phenomenon in the Pacific Northwest. In nearly all forested watersheds of Washington where land management activities have occurred, landslides, as a result of that management have provided the dominant sediment input to the associated aquatic system, far outpacing the naturally occurring rates. The goal of Washington's forest practices unstable slope rules is to prevent landslides due to forest management on state and private lands. The Landslide Hazard Zonation project was designed to assist land managers and regulators in determining the potential risk to public resources from forest management activities by mapping landslides and landforms that produce landslides. This type of approach produces a 'no surprises' relationship between landowners, stakeholders, and regulators working in the forested environment.

The project is designed as an integrated screening tool that exists and is utilized from GIS. The data is made available for free download. In order for the data to be useful and accessible to all stakeholder groups, a website that contains all of the watershed-based maps and reports in .PDF format is available for free download for those that do not have GIS. The project incorporates pre-existing landslide and landform information whenever possible and is the primary data repository for unstable slope studies in the state. At the beginning of this project, all available digital landslide inventories and mass wasting map units were collected and compiled into two GIS databases. These databases include both spatial and tabular data, to allow both spatial analyses of landslides and landform interactions, as well as statistical analyses.

A standardized mapping protocol was developed for all new data collection. This protocol is also posted on the website, so that other practitioners can use it. A team was assembled to map priority areas of the state. New data, as it is collected, is posted to the compilation and the GIS databases are updated on the internet quarterly. To date, over 42,000 individual mass wasting events have been mapped or compiled into the landslide database. Of these, 32,000 have tabular data associated with them. Ninety-five watersheds and land blocks have been compiled into the landform database (hazard zones). Over 1,100,000 acres have been mapped in the LHZ project, while an additional 2 million acres have been compiled from other studies.

An analysis of the landslide database indicate 70% of the landslides are identified as some form of shallow-rapid (debris slide, debris flow, or debris torrent); 1% of the landslides are identified as topples or falls; and the remaining landslides are considered some form of deep-seated landslide.

A comparison of mapping efforts and modeling efforts show that modeling estimates of instability for forested watersheds in Western Washington indicate approximately 13% of the land base is unstable. A comparison of the mapping compilation indicates that approximately 16% of the land base is rated as highly unstable. Nearly 20% was modeled as moderately unstable, only 12% of mapped areas are rated as moderate. For more details, see: www.dnr.wa.gov/forestpractices/lhzproject To download the compiled databases, go to: www.dnr.wa.gov/forestpractices/data "Landslides" and "Landslide Hazard Zones".